Absolute Zircon Ages for Pre-Necatrian Events and a Proposed Age for the Near Side Megabasin

Lunar Science Forum

July 20, 2010

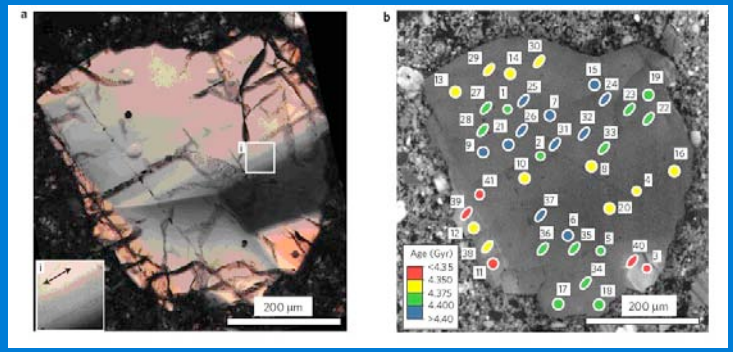

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Image Again

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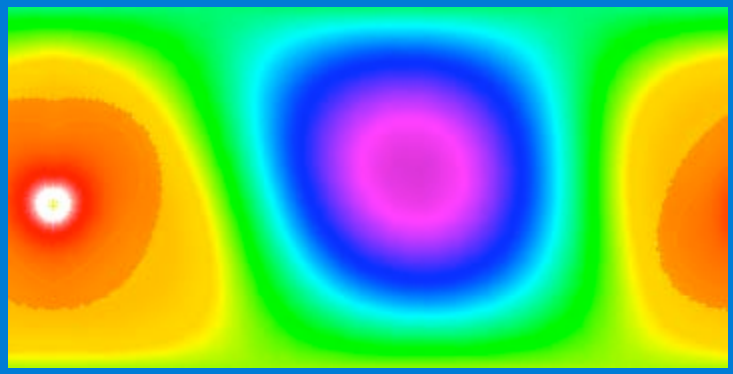
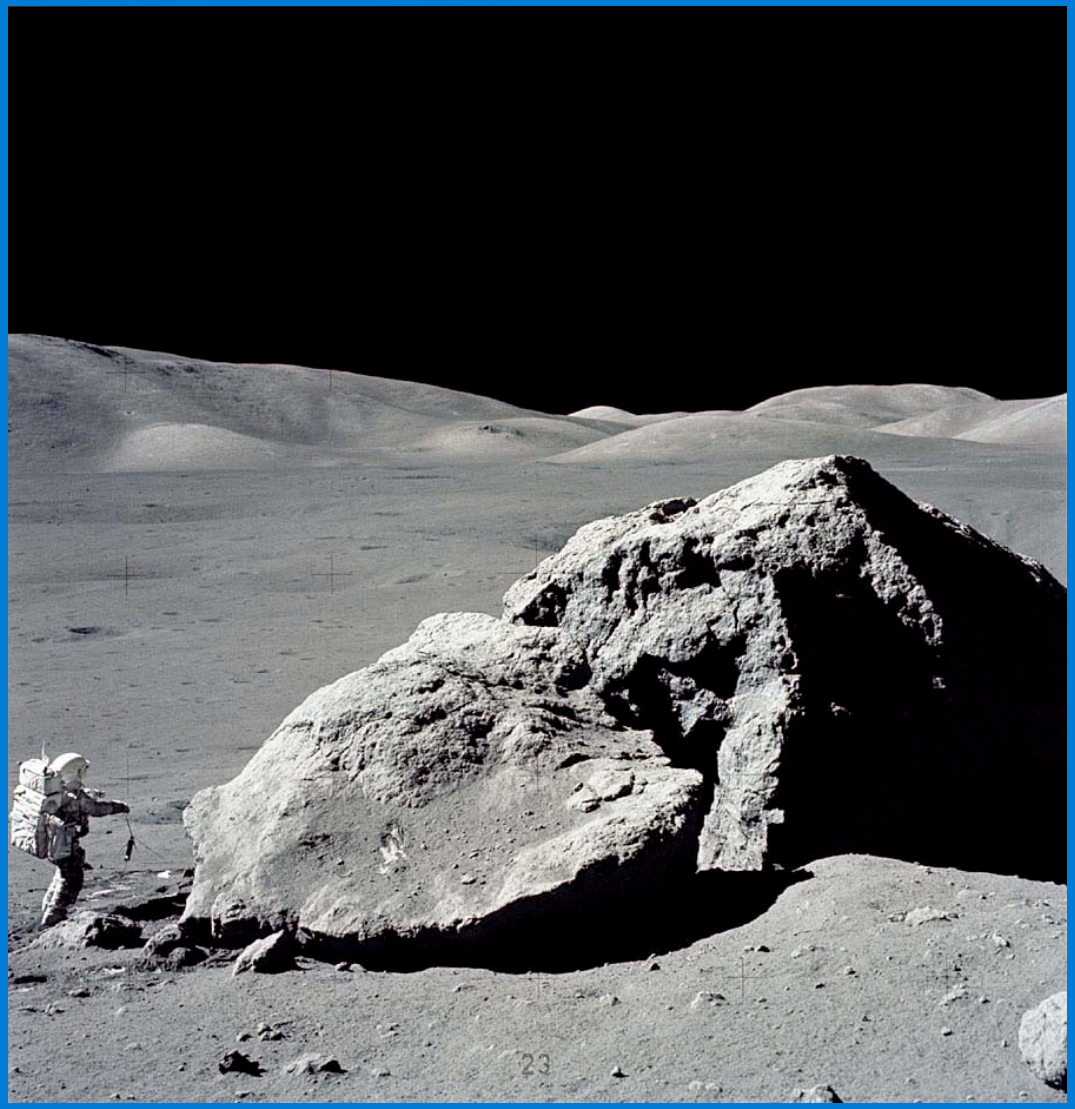


A Multi-disciplinary Study

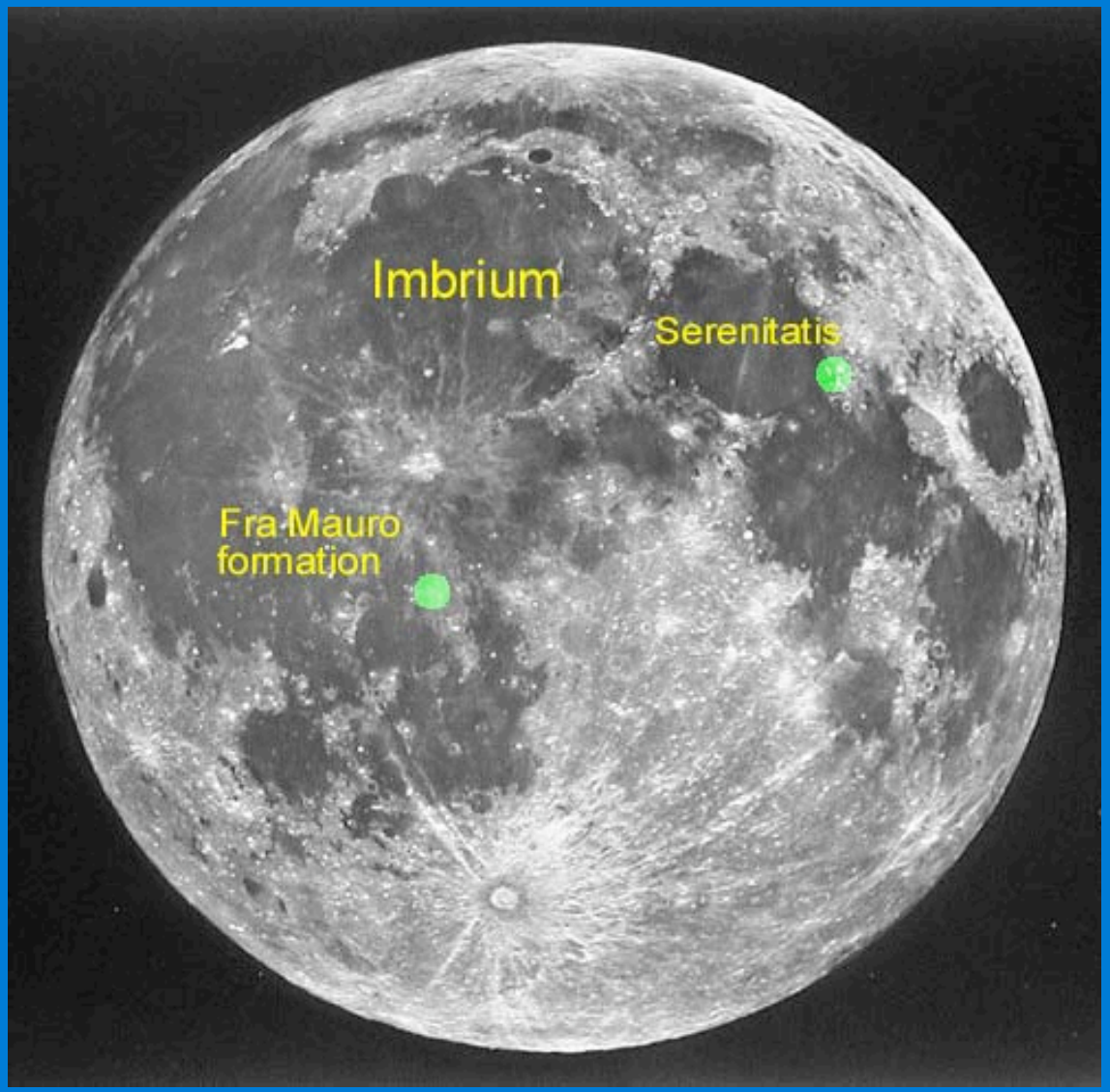
- Lunar Samples from Apollo (14, 17)
- Mineralogy (SHRIMP ion probe ages)
- Impact dynamics (shock and ejecta)
- Topography (shape of the Moon)

Samples from Apollo 14 and 17



Jack Schmitt takes a “chip off the old block”

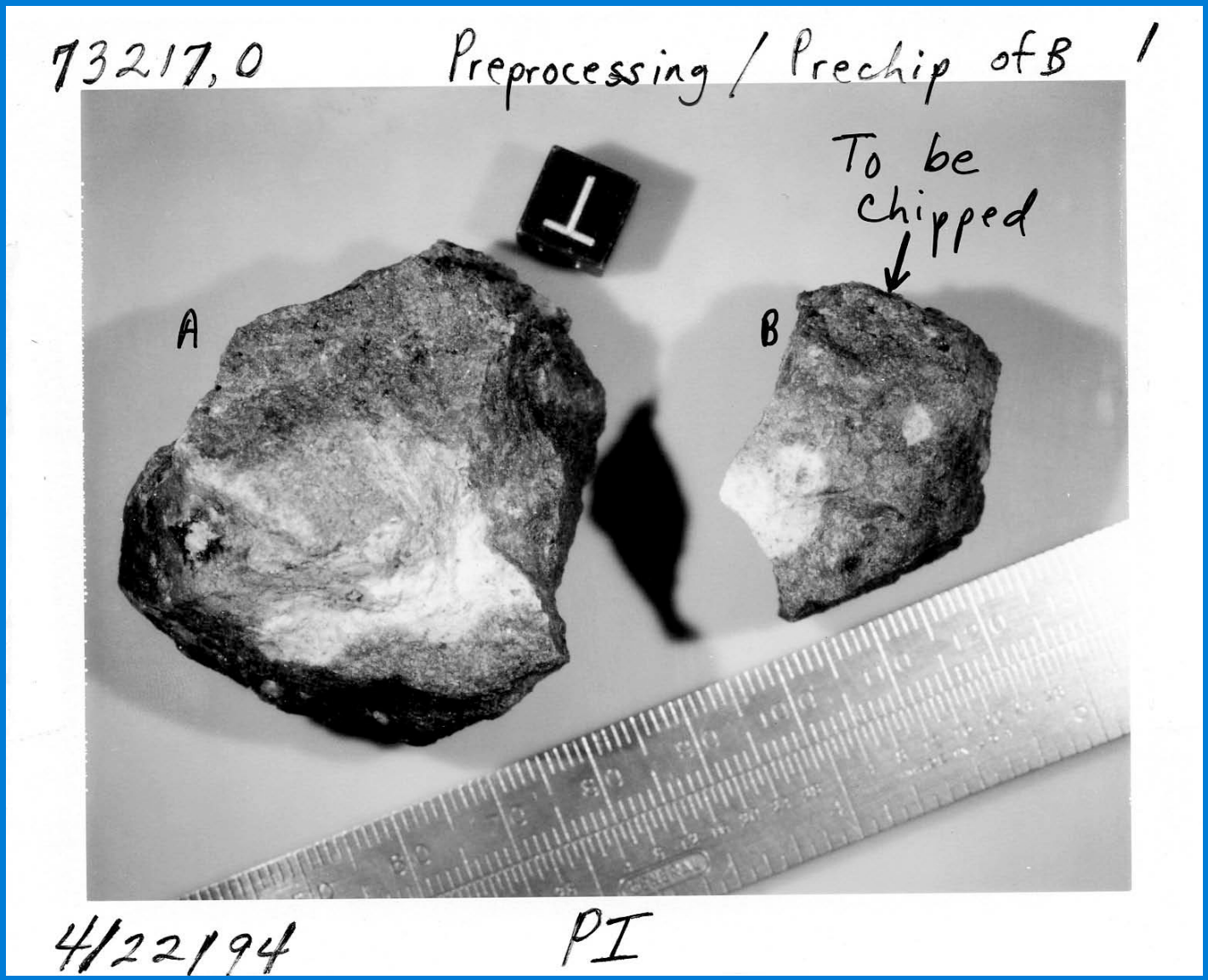
Apollo 14 and 17 Landing Sites



Apollo 17:
Taurus-Litrow v.
Serenitatis Rim

Apollo 14:
Fra Mauro form.
Imbrium ejecta

Apollo 17 Sample # 73217



Mineralogy: Ion Probe Analysis

- SHRIMP II: Sensitive High Resolution Ion Micro Probe
- < 50 μ resolution, 3 X 10^4 mass resolution

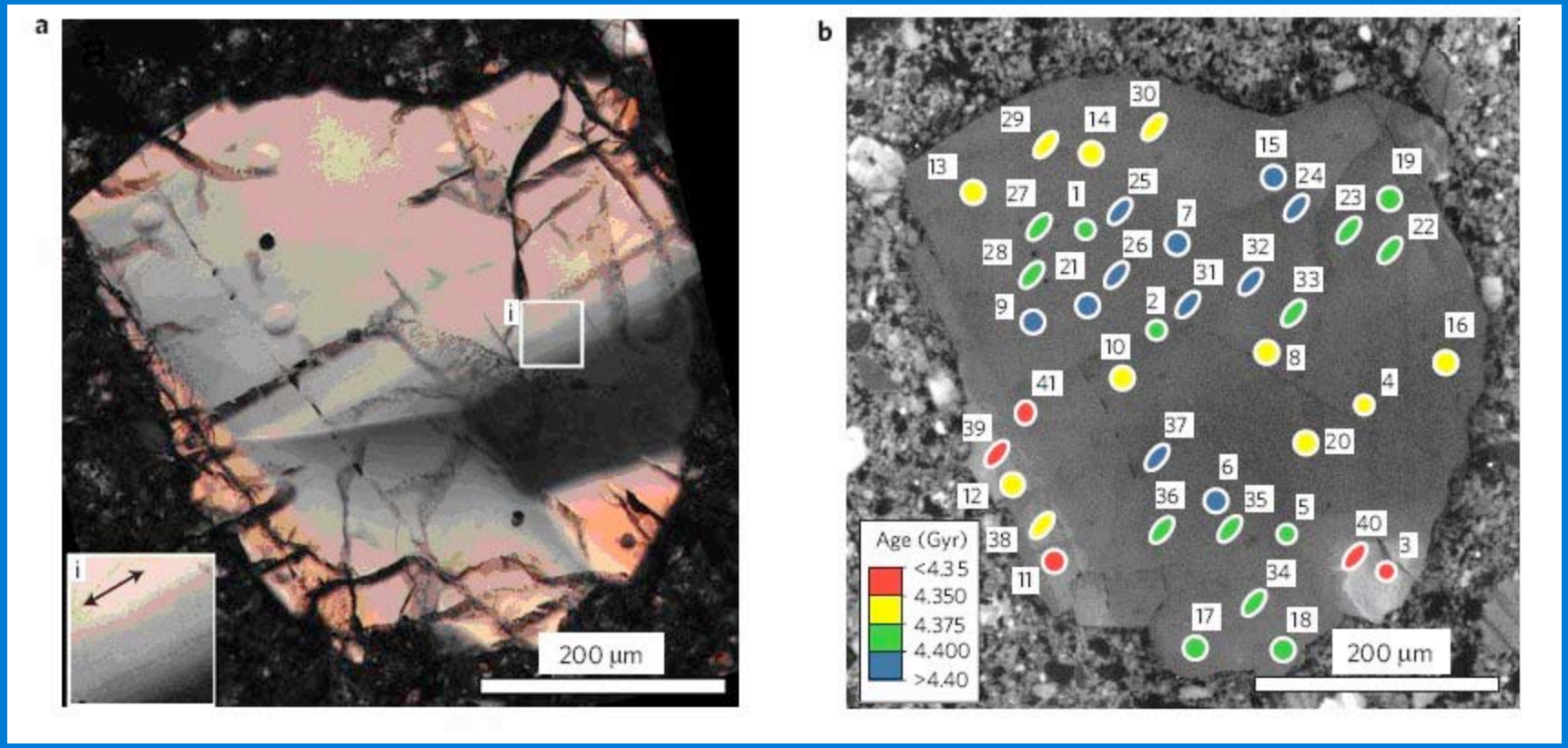
Zircons in Breccia

- The breccia samples have been shocked by impacts as they were ejected.
- They have aggregates of minerals, re-crystalized from melts or partial melts.
- Within them are crystals of the highly refractory zircon, that survives shocks.
- The age of ancient events is found from U/Pb decay of trace contaminants.

Ages of Most Sample Minerals

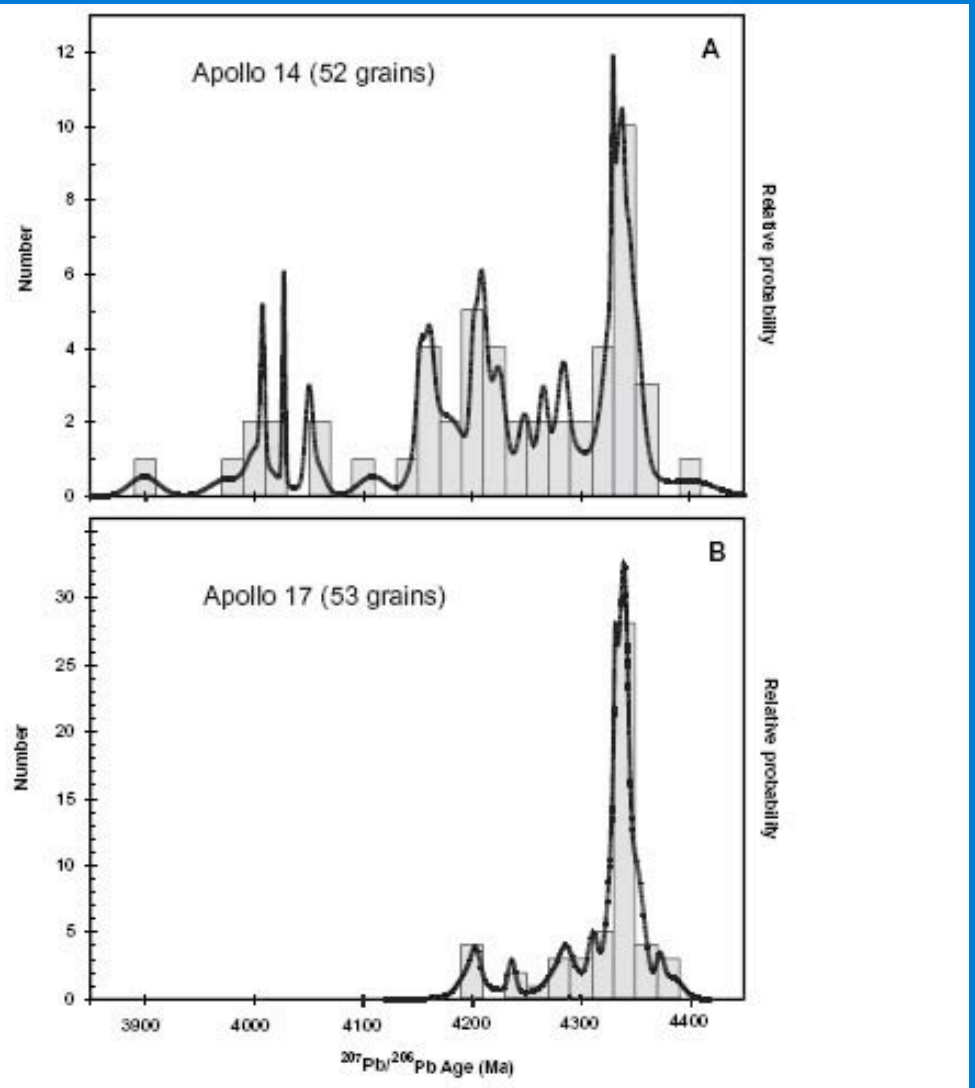
- Rocks from Imbrian ejecta have been aged at 3.77 Ga, the time of that impact.
- Rocks from the Serenitatis rim have been aged at 3.89 Ga, slightly older than Imbrium, in the Nectarian period.
- Within those rocks, zircons were found to have been formed much earlier.

Zircon in Thin Sample, 73215



Nemchin et al., 2009

Ages of Apollo Zircon Grains



Apollo 14 Peaks:

4.34 Ga
4.2 Ga
4.16 Ga
4.0 Ga

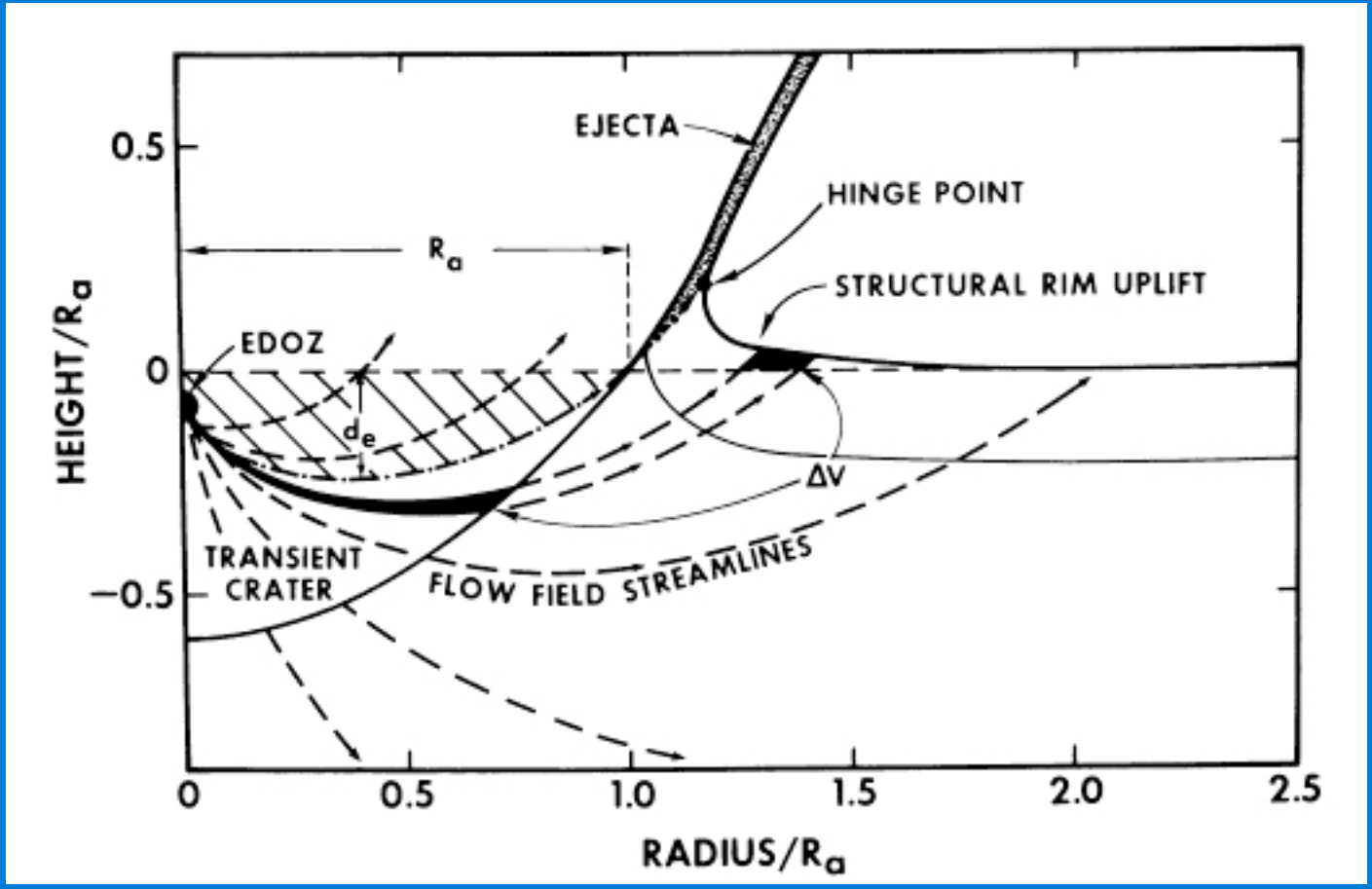
Apollo 17 Peak:

4.34 Ga

Nemchin et al., 2008

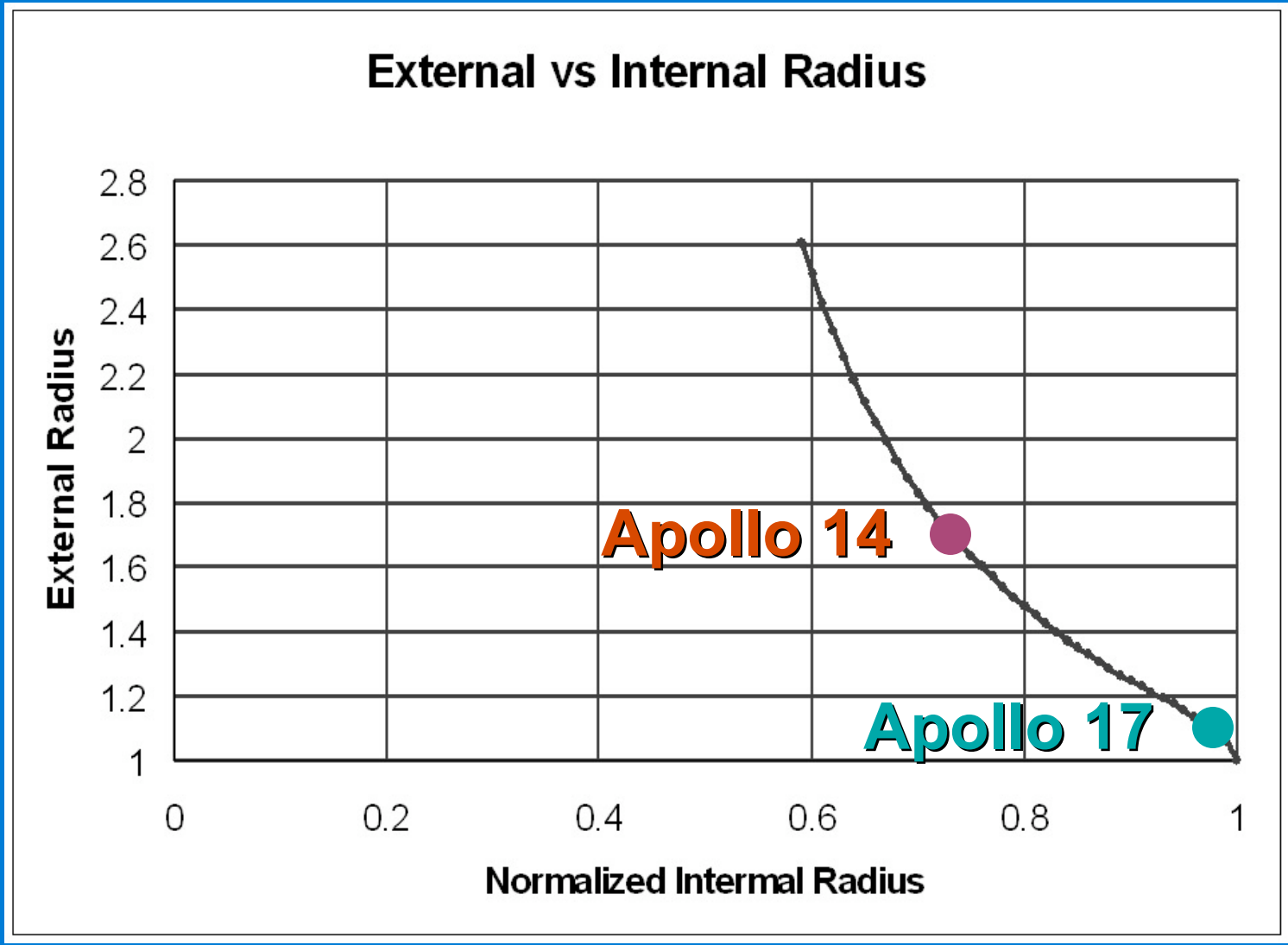
Impact Dynamics

Maxwell Z Model of Ejecta



Croft, 1981

Where Does Ejecta Come From?

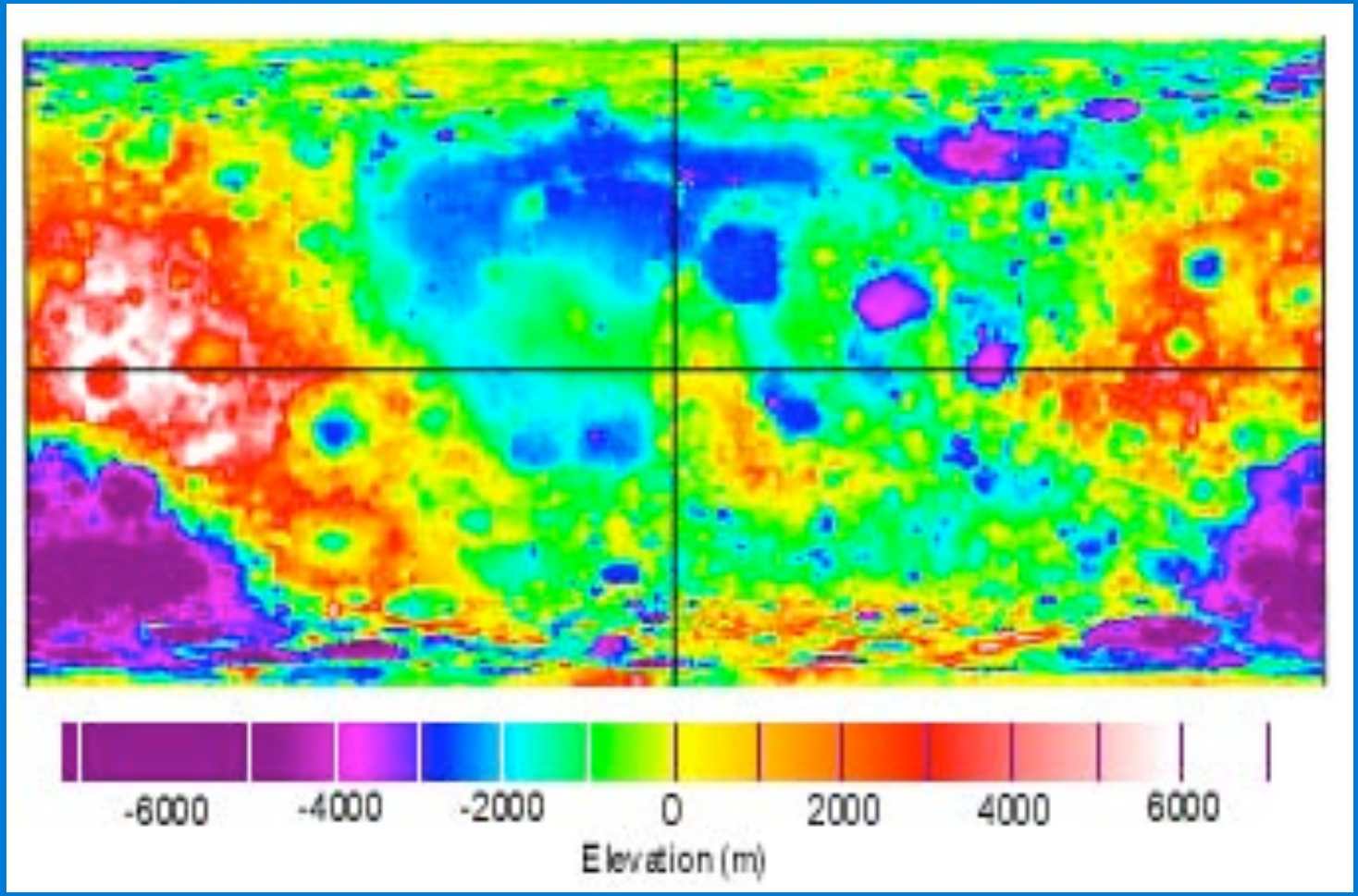


Where were these Zircons last?

- 4.34 Ga zircons dominate samples from widely separated near side locations
- Deep from Serenitatis, shallow from Imbrium
- Implication: a pervasive near side event
- Younger zircons are also from the shallow Imbrium pre-impact target
- Thrown there from earlier impacts (eg. Insularum)?

Evidence from Topography:

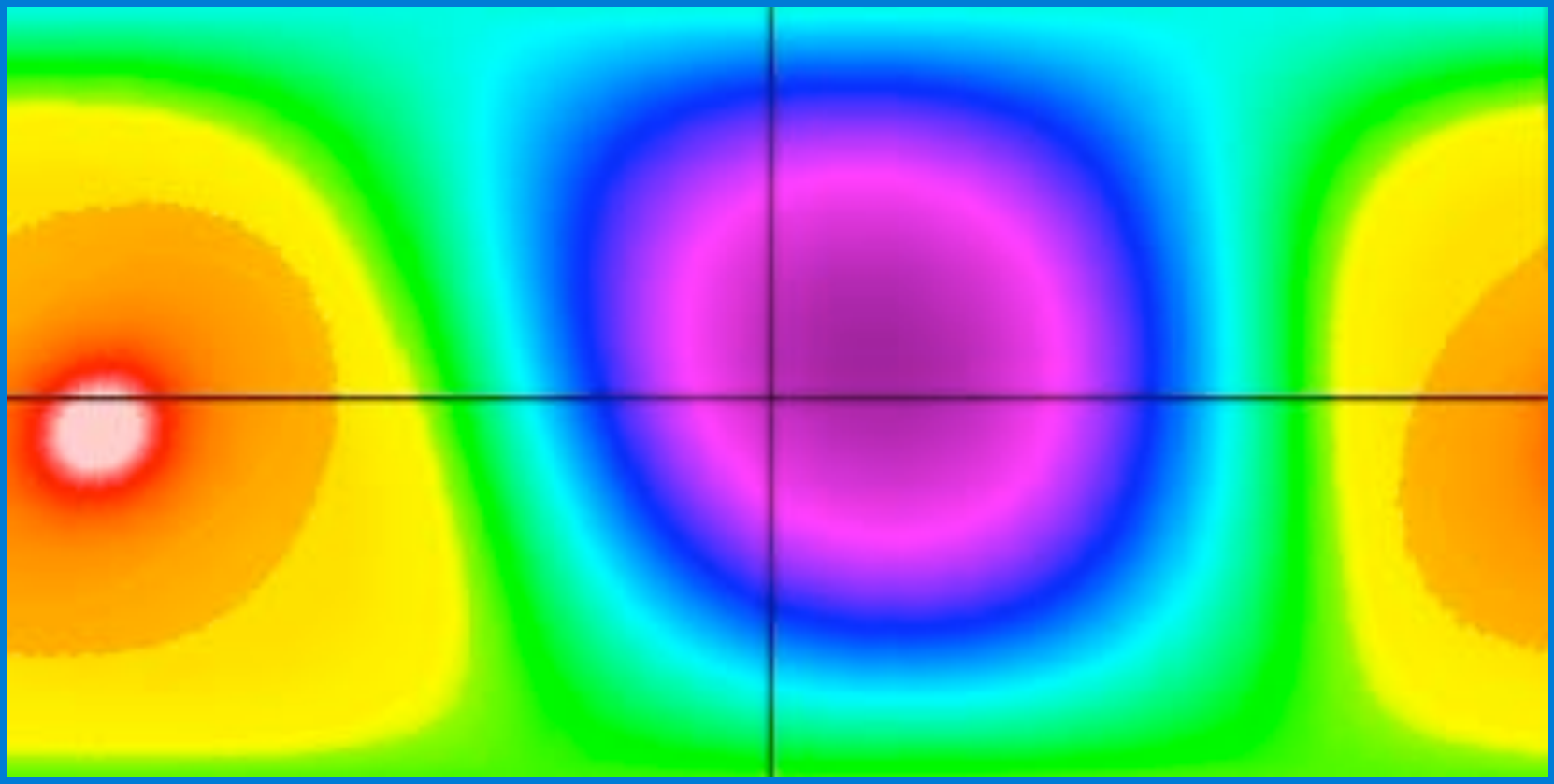
Clues to the pervasive near side event in the digital elevation map



What Caused this Shape?

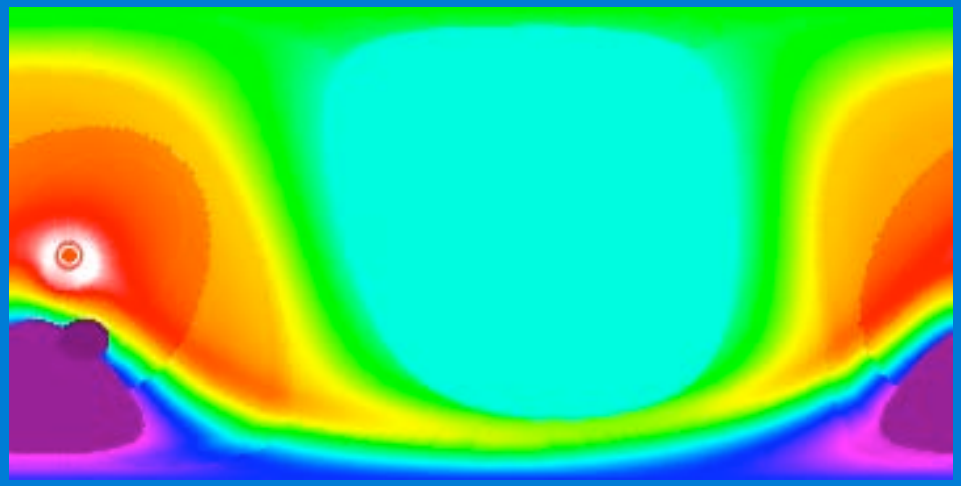
- The Moon has a depression of more than 1 km over most of its near side
- The far side is elevated, rising to a mound of about 5 km
- Gravity data: the crust is thinner on the near side and thicker on the far side.
- A giant near side impact, throwing its ejecta to the far side, may have shaped the Moon.

Model of the Near Side Megabasin

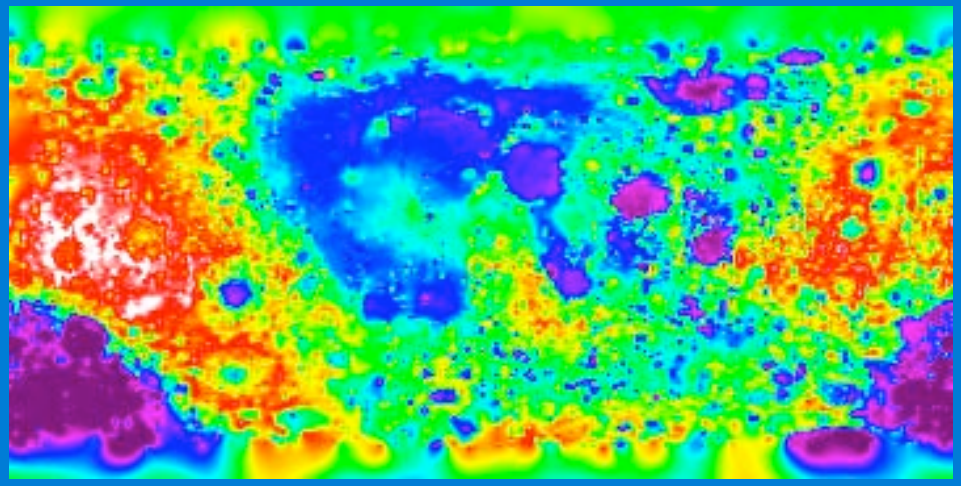


The NSM, before isometric compensation

The Two Giant Basins, after Compensation



Model of the Near Side Megabasin and the South Pole-Aitken Basin after compensation



Current topography

The Source of the 4.34 Ga Zircons

- Simulations show that giant basins cause melt columns beneath them
- A melt column in a thinned crust would have admixture from the incompatible layer
- Zircons there would have their ages reset
- The 4.34 Ga zircons could come from the remelted, and mixed crust of the NSM

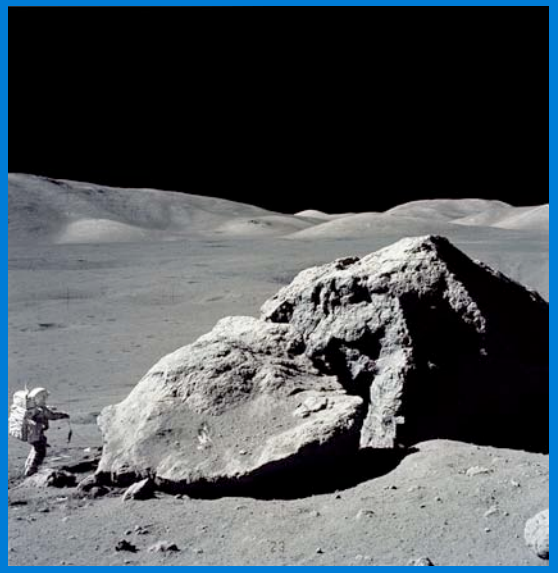
Summary

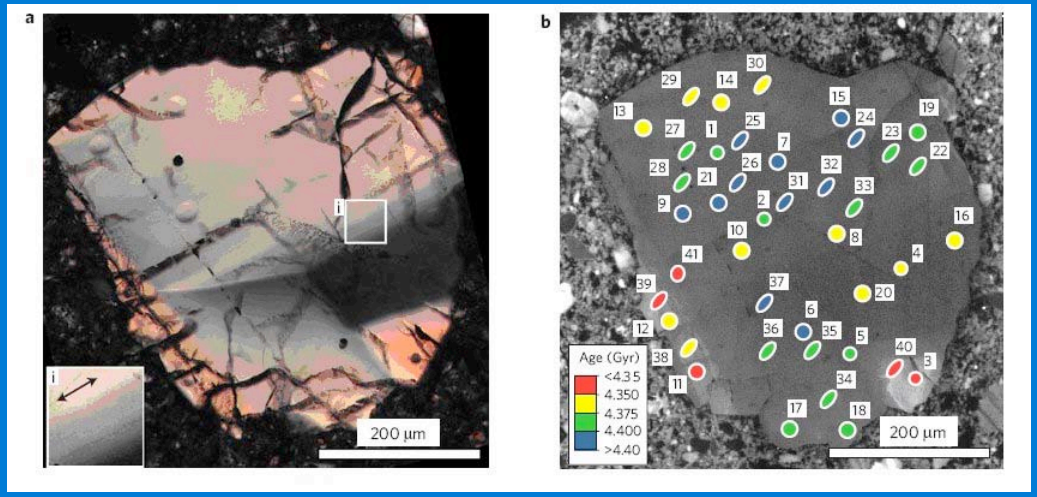
Multiple disciplines converge to suggest an answer to two questions:

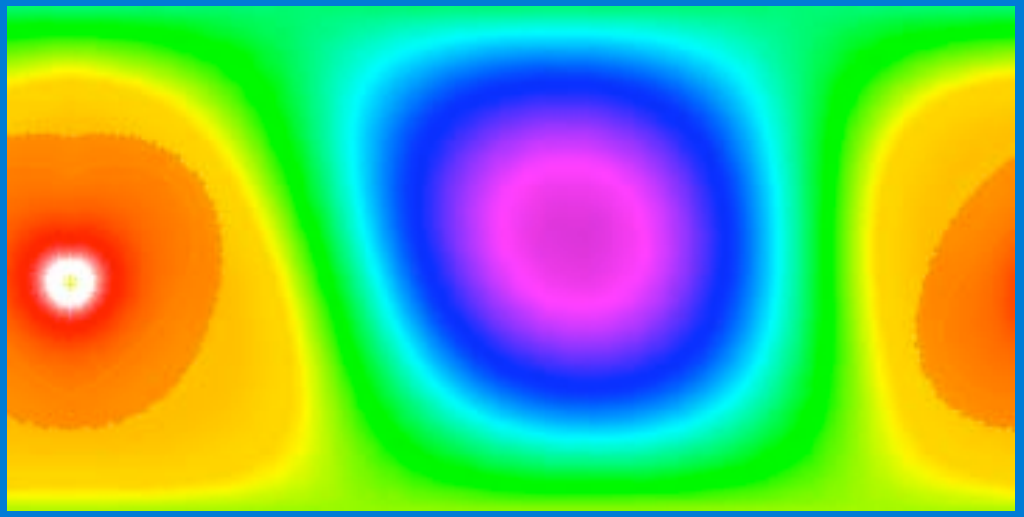
- What early cataclysmic event produced zircon ages of 4.34 Ga?
- What is the age of the Near Side Megabasin?

The Near Side Megabasin reset zircon grains at 4.34 Ga!

Questions?







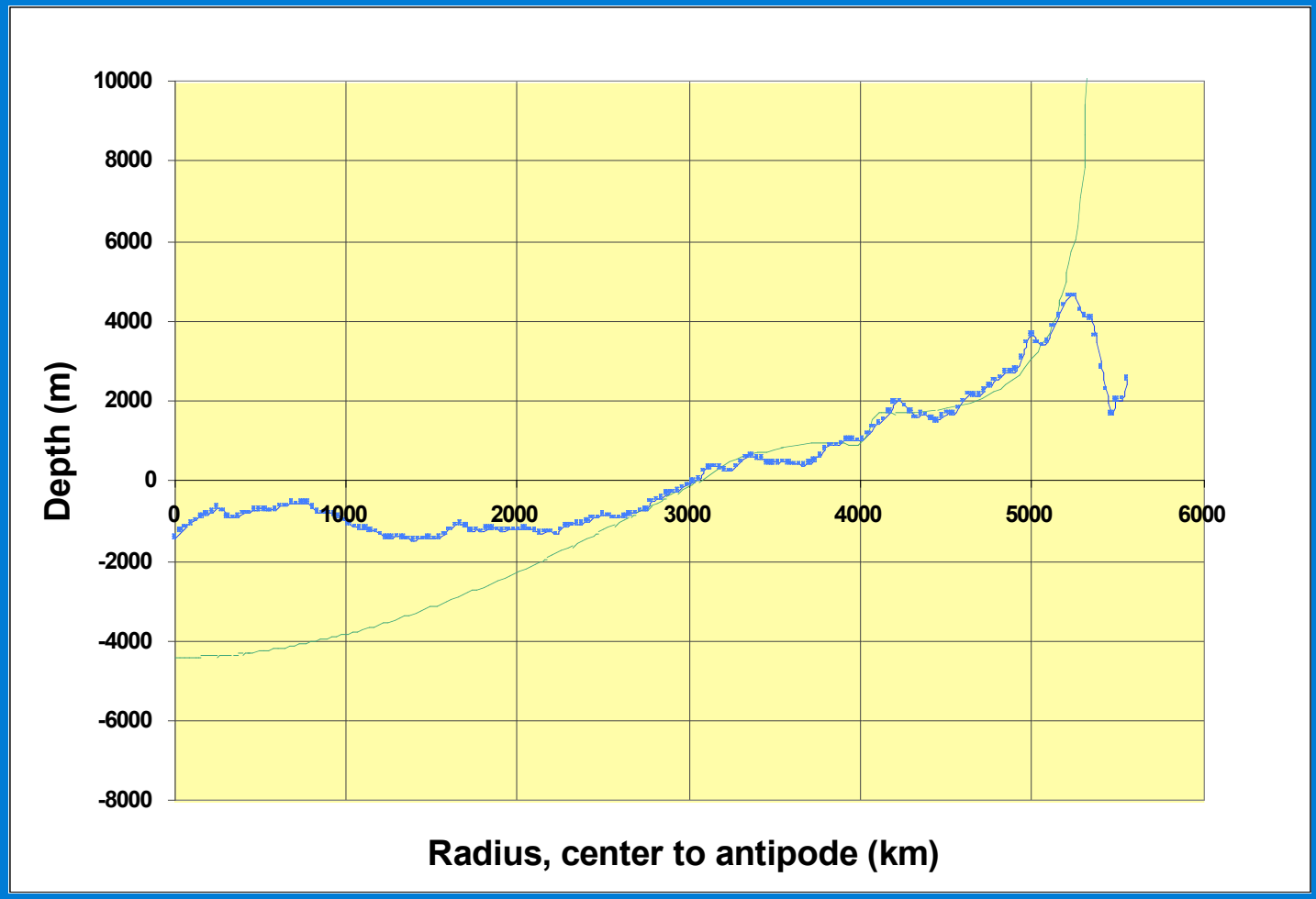
The Near Side Megabasin

Latitude:	08.5° N	Eccentricity	0.42
Longitude	22.0° E	Angle [1]	48°
Major axis radius	3320 km	Launch [2]	50°
Minor axis radius	3013 km		
Scale depth	4000 m		
Mare level	-1700 m		

[1] Angle of major axis, counter-clockwise from North

[2] Launch angle, measured from horizontal

Radial Profile of the Near Side Megabasin



The South Pole - Aitken Basin

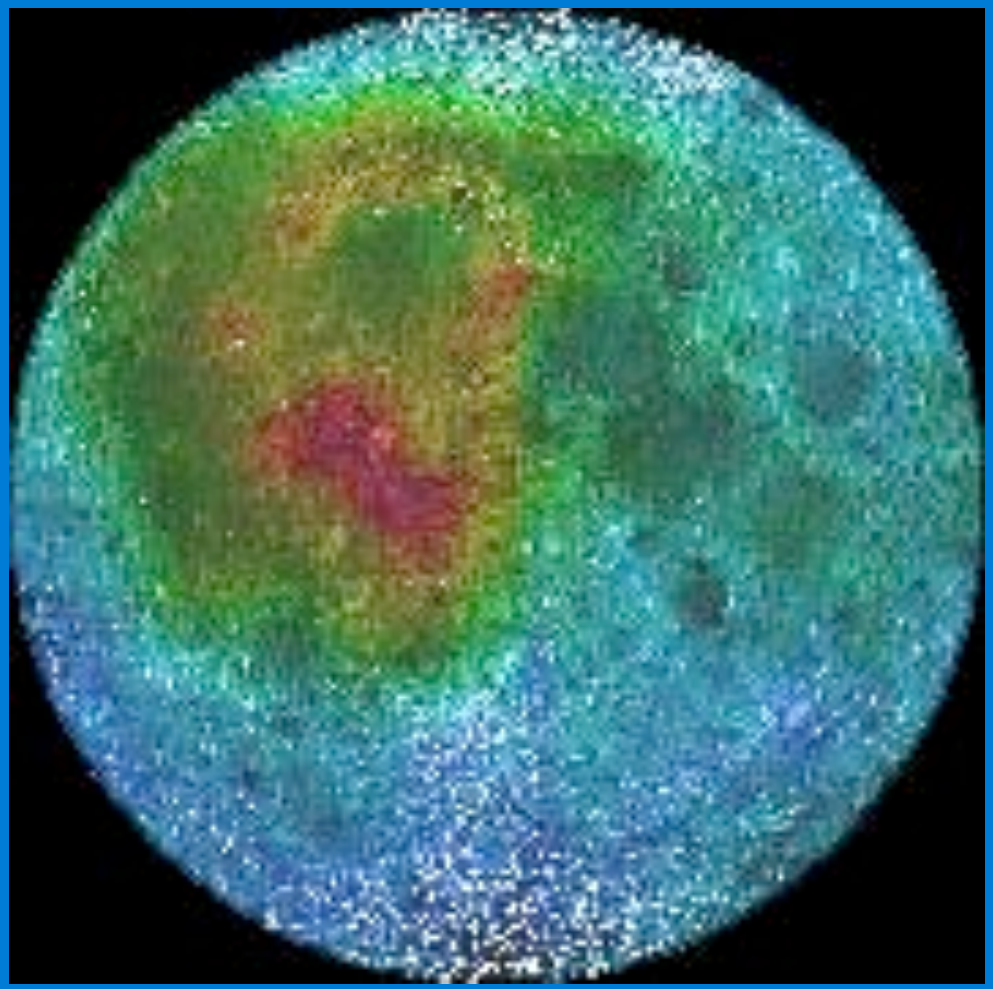
Latitude:	54.2 ^{o} S [1]	Eccentricity	0.69 [1]
Longitude	168.7 ^{o} W [1]	Angle	7.5 ^{o} [1]
Major axis radius	1440 km	Launch	42 ^{o}
Minor axis radius	1042 km		
Scale depth	6800 m		
Mare level	-4500 m (mare plus ejecta)		

[1] Garrick-Bethell, 2004, LPSC XXXV Abstract #1515

Additonal Investigation Needed

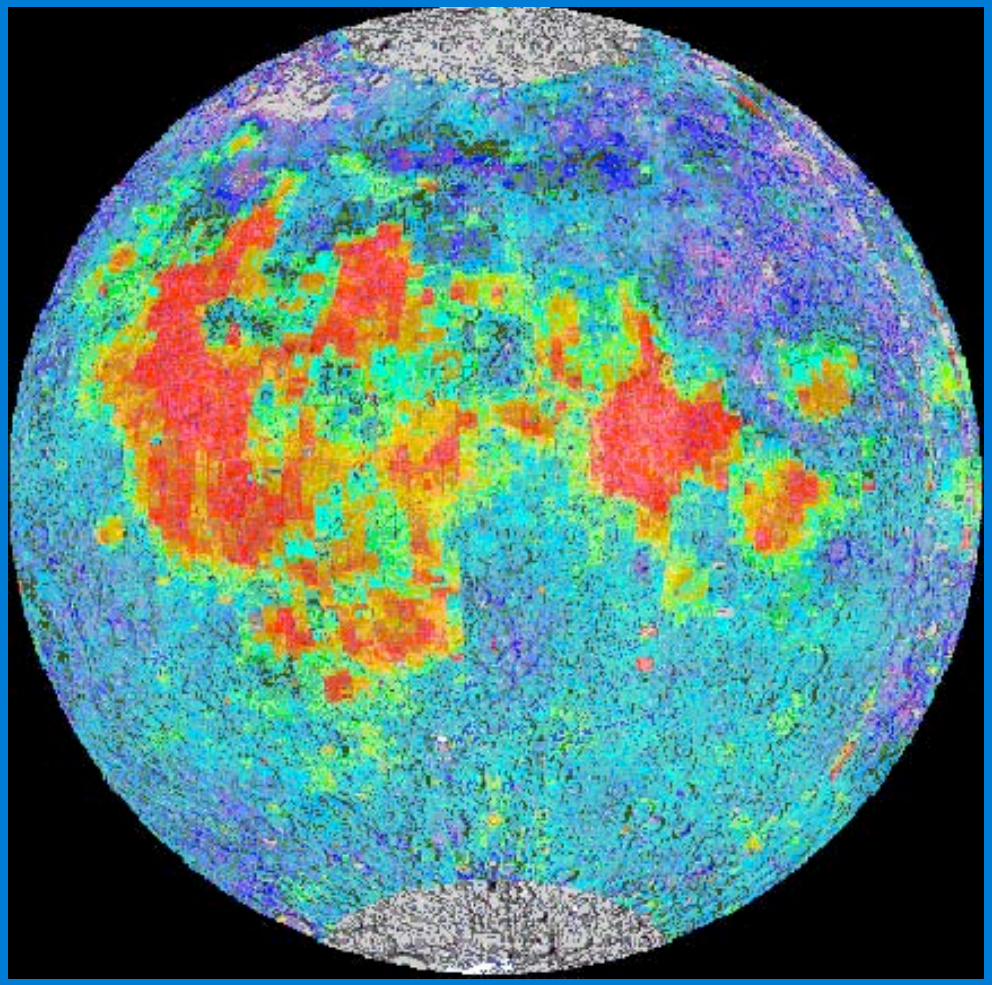
- Photo-geology study (rim, scarp, rings, ridges)
- Improved elevation data and photography
- Analysis of lunar Moho, centered on new basin
- Addition of smaller basins to the model
- Implications to early lunar history
- Simulations of ejecta velocity and launch angle
- Basin modeling (ellipse, spherical target)

Thorium Concentration Pattern



Element distributions can be explained by the admixture of material from the incompatible layer into the thinned crust below the Near Side Megabasin

Titanium



Iron